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Analyzing Alternative Hardwood Management Strategies

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ABSTRACT. An analysis of the per cubic foot investment costs associated with hardwood production under each of three management alternatives is presented: (1) plantation establishment; (2) a harvest cut followed by natural regeneration; (3) rehabilitation through timber stand improvement (TSI). The indication is that the vast majority of southern hardwood stands will continue to be naturally regenerated given landowner objectives, ownership patterns, and current stumpage prices.

Interest in more intensive management of hardwoods is growing. Thousands of acres of hardwood plantations are now being established annually across the South, particularly by forest industry. Further, these plantations are no longer restricted largely to cottonwood (*Populus deltoides* Bartr.) in the Mississippi Delta but include species such as green ash (*Fraxinus pennsylvanica* Marsh.), sycamore (*Platanus occidentalis* L.), water oak (*Quercus Nigra* L.), and sweetgum (*Liquidambar styraciflua* L.) as well as cottonwood on a variety of bottomland sites. Uses for hardwood species have been increasing while the quantity of accessible hardwood volumes of acceptable species and quality has been declining.

Management of hardwood stands is quite complex. Each stand has nearly unique species composition and specific site condition. Certainly there are some extremely good stands, but the typical hardwood stand is understocked with desirable species and contains many cull trees. This is especially true if the stand has been harvested within the last decade or so and there has been no management effort to encourage adequate regeneration. Given this situation, the principal alternatives for more intensive hardwood management are: (1) harvest the stand and establish a hardwood plantation; (2) perform a harvest cut and plan for natural regeneration of the site; and (3) rehabilitate the stand through timber stand improvement (TSI) work. This article attempts to determine the per cubic foot investment costs associated with hardwood production under each of these management alternatives. A recently cut-over, bottomland stand is assumed as the basis for analysis.

Financial analysis of hardwood plantations requires that current establishment costs are available. The establishment costs shown in Table 1 were obtained by visiting several industrial organizations actively engaged in hardwood plantation management and from supplemental information available from a questionnaire sent to large Mississippi forest landowners. "Typical" plantation establishment costs from Table 1 amount to $185 per acre but costs well above $200 per acre would not be uncommon.

Intensive site preparation is a critical factor for successful plantation establishment, according to the industrial firms surveyed. Sycamore was the principal species being considered for large plantation operations. Sycamore is favored over cottonwood since it is less site specific. A short rotation of from 12 to 20 years is planned for sycamore plantations followed by one or two coppiced stands.

Yield data are scarce for sycamore plantations, but the

Table 1. Current costs per acre of hardwood management practices.

Stand Type	Range	Typical
Plantations	1977 Dollars	
Site preparation[1]	50–175	150
Planting[2]	30– 44	35
Cultivation (first year)[3]	9– 30	
Pruning (age 4)	—	25
Annual costs	1– 4	2
Natural stands		
Timber stand improvement[4]	8– 60	25
Post-harvest stand preparation	20– 30	25

[1] *Low costs associated with cleaning the site and burning. High costs and the typical cost include shearing, raking, piling, burning, and disking.*
[2] *Spacing from 8 × 12 feet to 10 × 12 feet.*
[3] *High costs associated with two-way cultivation, twice the first year.*
[4] *Low costs for injection of only large cull trees. High costs associated with intensive injection and some precommercial thinning. Typical cost for injection of all cull trees.*

following information is available from Smith (1973):

Age (*years*)	Cubic feet per acre
5	550
10	1,926
15	3,147
20	4,213
25	5,124

While these yields are for stands on excellent sites, many early plantations (upon which these yield estimates are based) were not given sufficient cultivation. The full potential of sycamore plantations on excellent sites is better than indicated in these figures. For example, one plantation in Green County, Georgia, yielded 2,709 cubic feet at age 11.[1] Therefore, as was suggested by one industrial organization visited, the yields presented above are used as average yields for sycamore plantations in this analysis.

Assuming $185 per acre for plantation establishment, $15 per acre for cultivation, and an annual cost of $2 per acre, produces the investment costs shown in Table 2 for sycamore plantations. If land is considered an investment independent of growing timber because of rapid appreciation of land values, or if the owner is not interested in the option of selling the land, the top of Table 2 is relevant. Many private nonindustrial forest landowners have little interest in selling their forestland since they have both timber and nontimber goals for ownership.

On the other hand, if land cost is $175 per acre and an annual aftertax return equal to the interest rate times $175 is desired, then the lower portion of Table 2 is of most interest. The investment costs, with the cost of land included, consider valid the option of selling the forest land at $175 per acre and investing the money where it would earn the given rate of interest annually. Naturally land cost varies considerably over the South, depending on nearness to population centers, farming activity in the area, and other factors, but $175 per acre seems reasonable for many recently cut-over bottomland sites. A higher land cost would simply increase the with-land-cost figures presented in Table 2 by a constant amount.

Investment costs associated with plantation-grown wood are high. The optimum financial rotation for such plantations is between 15 and 20 years according to Smith's (1973) calculations. A cost of $0.20 per cubic foot is equivalent to a stumpage value of $15 per cord using 75 cubic feet of wood per cord. There is no historic trend in the stumpage price of hardwood pulpwood to indicate to the stumpage grower that hardwood plantations will be profitable from the stumpage grower's perspective, given the costs in Table 2. If some sawtimber can be produced in a 15-to 20-year rotation, however, the chances for profits would be improved. Similarly, there would be a chance for greater profit if lands were close to mills requiring large amounts of hardwood from non-company lands.[2]

[1]Unpublishment data supplied by Roger Belanger, Southeastern Forest Experiment Station, Athens, Georgia. Also see Kormanik, *et al.* 1973.

NATURAL REGENERATION

Another management option is to completely harvest the existing stand and plan for natural regeneration of the site. Yield information for naturally regenerated stands of hardwood is also scarce because mixed species composition makes growth and yield projections complicated. The most comprehensive study of growth and yield of natural hardwood stands was completed by members of the Hardwood Cooperative at North Carolina State University (Smith *et al.* 1975). Four of the forest site types defined in the Cooperative's study seem representative of the bottomland hardwood sites considered in this paper: bottomland (piedmont), branch bottom, and black and red river bottom sites (coastal plain). Sweetgum is the principal species present on all four of these site types.

Yields for branch bottom sites are intermediate and were used in this analysis as an average for "better" naturally regenerated stands. "Better" reflects the fact that severely high-graded stands were avoided in sample plot establishment in the Cooperative's study. However, there is no indication that the stands represented by the study received initial treatments to encourage better stand composition or growth. Yields for branch bottom sites follow:

Age (*Years*)	Total cubic feet per acre[1]	Sawtimber cubic feet per acre[2]
20	1,494	94
25	1,604	208
30	1,852	313
35	2,141	370
40	2,438	429
50	3,034	503

[1]Inside bark volume of apparent sound wood in main stems of trees 5.5 in. d.b.h. and larger to a 4-in. top (OB)
[2]Apparent sound cubic foot volume in trees 11.0 in. d.b.h. and larger to a 9-in. top (OB) - a portion of total cubic foot volume.

Assuming these yields are available with no post-harvest treatment, the only production costs are annual expenses. Using a $2 per acre annual cost for natural stands results in the investment costs per cubic foot shown in Table 3. The optimum financial rotation for such natural

[2]The full $185 establishment cost is charged against the first rotation in Table 2. Later coppice rotations will require less establishment costs and therefore some of the initial $185 could be "spread" to these later rotations. The final investment cost per rotation, given carrying charges, however will be somewhat higher than those in Table 2.

stands is between 20 and 25 years (Porterfield 1972, Holley 1976).

Comparing cost figures in Tables 2 and 3 provides an interesting conclusion. If the option of selling the land is not considered (land investment costs are not included) production of hardwood timber in natural stands is least expensive. Therefore, a private individual who does not consider land costs as part of his investment because he plans to pass his forestland on to the next generation or because he feels that the land will appreciate in value at or above the desired rate of interest, can produce hardwood timber cheaper in natural stands. A company may consider that it has limited opportunities to sell land if it is faced with a shrinking forestland base in its timbershed.

If the forest landowner demands a return on the total investment, land and timber, comparison of Tables 2 and 3 results indicates that investment in sycamore plantations minimizes per unit costs. This change in strategy produced by the inclusion of land cost has been previously discussed by Holley (1976) and results from (1) the longer time required for timber production in natural stands and (2) higher physical production in plantations, which allow land charges to be spread over more cubic feet.

Tables 2 and 3 present only the cost side of the financial analysis. But, clearly, hardwood plantations appear profitable from the stumpage growers' perspective only if stumpage prices for hardwood increase substantially. Natural branch bottom stands in comparison, can earn well over 10 percent interest at 20 years if land cost is ignored.[3] Returns are as low as 4 percent if land cost is considered (Porterfield 1972).

Table 2. Future investment per cubic foot of wood harvested from sycamore plantations based on per acre costs of $185 for establishment, $15 for cultivation, and $2 annual costs.

	Age at harvest	Total volume at harvest	Interest rate and before (BT) and after tax (AT) designations					
			6%		*8%*		*10%*	
	Yrs.	*Cu. ft.*	*BT*[1]	*AT*[2]	*BT*	*AT*	*BT*	*AT*
WITHOUT LAND COST	10	1926	$.20	$.16	$.24	$.20	$.29	$.25
	15	3147	.17	.14	.22	.19	.29	.26
	20	4213	.17	.15	.24	.22	.35	.32
WITH LAND COST	10	1926	.27	.23	.35	.31	.43	.39
	15	3147	.25	.22	.34	.31	.47	.44
	20	4213	.26	.24	.39	.37	.59	.56

[1] $(\$2.00)\dfrac{(1.0+i)^n-1.0}{(i)}$ *+ $200* $(1.0+i)^n$*/current yield (cultivation treated as an expense the first year) plus ($175)* $(i)\dfrac{(1.0+i)^n-1.0}{(i)}$*/current yield, for "With Land Cost"*

[2] $(\$1.04)\dfrac{(1.0+1)^n-1.0}{(i)}$ *+ $200* $(1.0+i)^n - .3(\$200)$*/current yield – after tax figures computed at corporate tax rates – plus ($175)* $(i)\dfrac{(1.0+i)^n-1.0}{(i)}$*/current yield, for "With Land Cost"*

REHABILITATE THE STAND

A third management alternative is to rehabilitate the existing stand. Utz and Balmer (1970) reviewed available work and found that rehabilitation is sometimes more profitable than stand regeneration. The principal determinant of profitability is the residual stocking level of desired species.

Because only limited response data are available for timber stand improvement (TSI) treatments, a stand simulation model was utilized to estimate the financial investment costs following TSI work (Killcreas 1976)[4]. An initial species composition characteristic of forest inventory data for the Mississippi coastal plain, weighted to soft hardwoods such as sweetgum, was assumed in the stand simulation model. A recently cut-over stand was assumed and all cull trees were removed through the expenditure of $25 per acre for TSI work (Table 1). Three levels of residual, desirable growing stock basal area were analyzed: 32, 56 and 80 square feet per acre. In other words, after cull tree removal, these stocking levels were the total basal areas remaining in the three stands to be simulated. The $25 for TSI was not varied with the level of residual basal area since the total BA before TSI was uncertain. A substantial amount of TSI work can be done with $25 per acre, however. Post-TSI stand structures used for the three simulated stands were:

Diameter class (in.)	Initial number of desirable stems per acre by beginning basal area[1]		
	32 BA	56 BA	80 BA
6	40	70	100
8	24	41	59
10	15	25	37
12	10	18	25
Total stems	89	154	221

[1]Merchantable volume in 14 inch d.b.h. class and above removed at harvest. Other trees in 14 inch d.b.h. class and above removed as culls through TSI work.

Two growth periods following TSI were considered: 10 and 20 years. The 20-year period proved too long when the initial residual basal area was 80 square feet, however. The basal area in this stand grew so large that an intermediate cut would be necessary prior to 20 years just to keep the stand growing. Yields for the simulated stands follow:

[3]Pulpwood valued at $6 per cord and sawtimber at $80/MBF, using 75 cubic feet cord and 6 bd. ft./cubic foot.

[4]We are indebted to Keith Blatner, who received a master of science in forest economics at Mississippi State, for assistance in obtaining the computer simulation results.

Age since TSI (*years*)	Initial BA after TSI (*sq. ft.*)	Total[1] volume (*cu. ft.*)	Total growth (*cu. ft.*)	Sawtimber[2] growth (*cu. ft.*)
	Per acre			
10	32	986	540	188
10	56	1,881	1,054	361
10	80	2,894	1,649	558
20	32	2,037	1,591	875
20	56	3,993	3,166	1,719

[1]Cubic feet of growth plus initial cubic foot volume, includes volume in trees 5.1 inches d.b.h. and larger to a 4-inch top.
[2]Cubic foot volume in trees 13.6 inches and larger in d.b.h. to a 10-inch top.

Using a $25 per acre TSI cost and $2 per acre annual cost results in the investment costs shown in Tables 4 and 5 for the 10-and 20-year growth periods, respectively. Compounded costs are per cubic foot of total growth in these tables because only costs and growth since TSI work provide valid comparative figures. An evaluation of growth reponse due solely to TSI cannot be made, since the growth attainable on the residual trees without TSI is not known. Whether investment costs are expressed on the basis of growth in volume or total volume (initial volume plus growth) does not change the conclusions reached below.

Comparing Tables 4 and 5 indicates that the investment cost at 8 percent interest and without land costs is lower for the 20-year post-TSI period. The fact that cost per cubic foot declines somewhat between 10 and 20 years means that the stand is growing faster than 8 percent. At 10 percent interest, investment costs at 10 and 20 years are equal when land cost is not considered, but investment cost is less for the 10-year response period when a rent for land cost is charged.

Table 3. Future investment per cubic foot of wood harvested from natural stands (branch bottom sites) based on per acre costs of $2 per year.

	Age at harvest	Total volume at harvest	Interest rate and before (BT) and after tax (AT) designations					
			6%		8%		10%	
	Yrs.	*Cu. ft.*	*BT*[1]	*AT*[2]	*BT*	*AT*	*BT*	*AT*
WITHOUT LAND COST	20	1494	$.05	$.03	$.06	$.03	$ .08	$ .04
	25	1604	.07	.04	.09	.05	.12	.06
	30	1852	.09	.04	.12	.06	.18	.09
WITH LAND COST	20	1494	.31	.29	.49	.46	.75	.71
	25	1604	.43	.40	.73	.69	1.19	1.13
	30	1852	.54	.49	.98	.92	1.73	1.64

[1]*($2.00)* $\frac{(1.0 + i)^n - 1.0}{(i)}$ */current yield – plus ($175) (i)* $\frac{(1.0 + i)^n - 1.0}{(i)}$ */current yield for, "With Land cost"*

[2]*($1.04)* $\frac{(1.0 + i)^n - 1.0}{(i)}$ */current yield – plus ($175) (i)* $\frac{(1.0 + i)^n - 1.0}{(i)}$ */current yield for, "With Land cost"*

Comparisons between the simulation results (Tables 4 and 5) and investment costs for natural stand regeneration (Table 3) and plantations (Table 2) are speculative. However, the conclusions from such comparisons do seem reasonable. Excluding consideration of land cost, the financial decision is between rehabilitation and natural stand regeneration (Table 3 *vs*. Table 4, for example). If only 32 square feet of desirable growing stock remains after TSI, complete stand regeneration should be favored. With 56 square feet of basal area after TSI, costs are similar, but natural stand regeneration with a 20-year rotation would be favored. If the residual stand after TSI contains 80 square feet of basal area, however, results indicate that rehabilitation of the stand should be favored. Plantation-grown wood (stumpage) has the highest cost per cubic foot when land costs are excluded.

If land cost is included, the financial comparison is between rehabilitation and plantation establishment and results are similar to those above. At the low initial basal areas, costs are lower for plantation-grown wood. At 80 square feet of basal area, rehabilitation produces less expensive wood. Few recently cut-over hardwood stands could be expected to have 80 square feet of basal area after TSI, however.

APPLICATION

Realistically there is small likelihood that the private nonindustrial forest landowner can be interested in hardwood plantation management for the production of pulpwood. Risk is high, his alternative rate of return is high, and out-of-pocket expenses would be high, even with a 75 percent cost-sharing program such as the Forestry Incentives Program (FIP). The nonindustrial forestland-owner may very well consider ownership of forest land an independent investment and therefore can produce timber at a satisfactory rate in naturally regenerated stands. The fact that TSI will produce wood with the least investment cost, provided an adequate stand of desirable stems remains after treatment, is relevant for small nonindustrial forest ownerships. The nonindustrial landowner will want to minimize out-of-pocket expenses in most cases. Availability of cost-sharing funds will make rehabilitation even more attractive.

The perspective is different for corporate forestlands. The greater the proportion of hardwood needs produced on fee lands, the lower the risks associated with fluctuating open market supplies and prices. Also, forest industry cannot ignore the fact that greater volumes of wood are produced in plantations even though costs are higher. In 15 years the sycamore plantation yields 3,147 cubic feet per acre while the naturally regenerated branch bottom stand yields 1,604 cubic feet per acre in 25 years. If a mill requires 100,000 cords of hardwood each year and desires that one-half of this volume be

available from company lands, 17,874 acres of plantation would be required whereas 58,438 acres of natural stands would be required. The savings in land investment and management costs with plantations would exceed $7 million using a land value of $175 per acre.

Since timber companies process purchased wood, they are also keenly interested in costs beyond the stumpage growers' perspective. Delivered cost of wood to the mill or rail concentration point is quite important. Therefore, if there is a substantial reduction in harvesting costs associated with plantation-grown hardwood, the net delivered wood cost per unit (savings in harvesting cost net of the higher stumpage investment costs) could actually be lower for hardwood plantations. The more uniform plantation-grown wood would no doubt reduce sorting and manufacturing costs as compared to the heterogeneous natural stands. Thus, costs beyond the stump can also explain why companies might favor plantation establishment as a management strategy if they must have hardwoods.

Table 4. Future investment per additional cubic foot of wood harvested from a natural stand 10 years after TSI work based on costs of $25 per acre for TSI and $2 per acre annual costs.

	Initial BA	Volume growth after 10 years	Interest rate and before (BT) and after tax (AT) designations					
			6%		8%		10%	
	Sq. ft	*Cu. ft.*	*BT*[1]	*AT*[2]	*BT*[1]	*AT*[2]	*BT*[1]	*AT*[2]
WITHOUT LAND COST	32	540	$.13	$.07	$.15	$.08	$.18	$.09
	56	1054	.07	.04	.08	.04	.09	.05
	80	1649	.04	.02	.05	.03	.06	.03
WITH LAND COST	32	540	.39	.33	.53	.46	.70	.61
	56	1054	.20	.17	.27	.23	.35	.31
	80	1649	.12	.10	.17	.15	.23	.20

[1] $(\$2.00)\frac{(1.0+i)^{10}-1.0}{(i)} + \$25\,(1.0+i)^{10}$ *additional yield – plus*

$(\$175)\,(i)\frac{(1.0+i)^{10}-1.0}{(i)}$ */additional yield, for "With Land cost"*

[2] $(\$1.04)\frac{(1.0+i)^{10}-1.0}{(i)} + \$13\,(1.0+i)^{10}$ *additional yield – plus*

$(\$175)\,(i)\frac{(1.0+i)^{10}-1.0}{(i)}$ */additional yield, for "With Land cost"*

Table 5. Future investment per additional cubic foot of wood harvested from a natural stand 20 years after TSI work based on $25 per acre for TSI and $2 per acre annual costs.

	Initial BA	Volume growth after 20 years	Interest rate and before (BT) and after tax (AT) designations					
			6%		8%		10%	
	Sq. ft	*Cu. ft.*	*BT*[1]	*AT*[2]	*BT*	*AT*	*BT*	*AT*
WITHOUT LAND COST	32	1592	$.10	$.05	$.13	$.07	$.18	$.09
	56	3166	.05	.03	.07	.03	.09	.03
WITH LAND COST	32	1591	.34	.29	.53	.47	.81	.72
	56	3166	.17	.15	.27	.23	.41	.37

[1] $(\$2.00)\frac{(1.0+i)^{20}-1.0}{(i)} + 25\,(1.0+i)^{20}$ *additional yield – plus*

$(\$175)\,(i)\frac{(1.0+i)^{20}-1.0}{(i)}$ */additional yield, for "With Land cost"*

[2] $(\$1.04)\frac{(1.0+i)^{20}-1.0}{(i)} + 13\,(1.0+i)^{20}$ *additional yield – plus*

$(\$175)\,(i)\frac{(1.0+i)^{20}-1.0}{(i)}$ */additional yield, for "With Land cost"*

– after tax figures computed at corporate tax rates

Another important reason why industry might accept the higher price of plantation wood is the concept of "marginal" wood needs. Suppose a mill is paying $4 per cord ($0.05 per cubic foot) for hardwood pulpwood now and is utilizing 100,000 cords per year. Further suppose that a *planned* expansion of mill capacity will require an additional 10,000 cords. How can the additional or marginal wood be obtained at minimum cost? The company can establish 3,575 acres of sycamore plantations over the next 15 years (238 acres per year) and these lands will yield the required 10,000 cords annually beginning 15 years from now. The additional cost will be (using 8 percent interest and before taxes) 10,000 times $16.50 (75 cubic feet per cord × $0.22 per cubic foot; see Table 2) or $165,000. The alternative method of obtaining the additional 10,000 cords might be to raise the hardwood stumpage price by $1.50 per cord. However, this increase would have to be paid on each cord harvested; a total increase of 100,000 × $1.50 + 10,000 × $5.50, or $205,000. Admittedly, this example is "rigged" but it demonstrates the marginal wood concept.

Another advantage of plantations is that they allow the use of genetically improved material. Tree improvement work with hardwoods is considerably behind that with pine but early indications are that hardwoods, sycamore for example, show heritabilities (the ability of a parent to pass on a good trait to its offspring) greater than those of pines. Thus, application of tree improvement holds promise for very substantial gain in the first generation.

For companies that do not have an absolute hardwood requirement, natural regeneration or stand rehabilitation will likely be considered the only reasonable hardwood management strategies from a financial view. The choice between these two alternatives depends on the level of residual, desirable growing stock after TSI. One advantage with TSI is the fact that expenditures may be expensed for tax purposes. Another factor is that stand rehabilitation holds company options open. If the need for hardwoods is not critical, TSI offers good growth on large stems. A company can produce wood at a minimum investment and react to changing fiber or solid wood market conditions. Following TSI, the stand will be producing more wood than unmanaged stands and can always be harvested if market conditions dictate.

This financial analysis indicates that hardwood plantation establishment will be continued by those com-

panies in need of hardwood. As shown above, there may be one or more reasons for companies to establish hardwood plantations even though the investment cost is high. These plantations will no doubt be established on good company lands near the mill (to reduce hauling costs) and will be managed intensively. However, this analysis indicates that the vast majority of southern hardwood stands will continue to be naturally regenerated as long as stumpage prices remain near current levels. Most southern hardwood stands are in nonindustrial private ownerships. These owners have strictly a stumpage grower's perspective and, regardless of the treatment of land cost, the investment in plantation-grown hardwood seems to exceed likely returns. Additionally, nontimber objectives for hardwood stand ownership may be better attained in natural stands. Timber stand improvement holds promise, especially for nonindustrial ownerships, with existing stands not severely high-graded, since the investment is low and the growth response is both rapid and substantial. It is clear from this work that ownership objectives and the present condition of existing stands are the prime determinants in the formulation of appropriate hardwood management strategies.

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